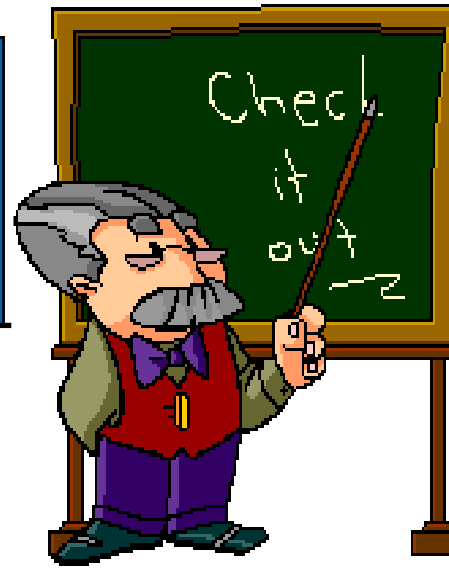
Moisture Damage? The Mastic Matters!

National Moisture Damage Workshop

San Diego
February - 2003

Moisture Damage:
A different point of view!



What's wrong with the mastic?

- *–Binder sensitivity to moisture*
- *–P200 - the hidden emulsifiers*

Hamburg Wheel-Tracking

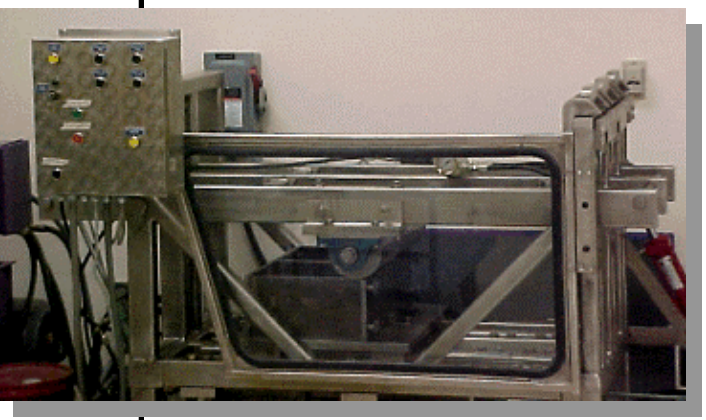
Why proof tests?

Isn't SuperPave enough?

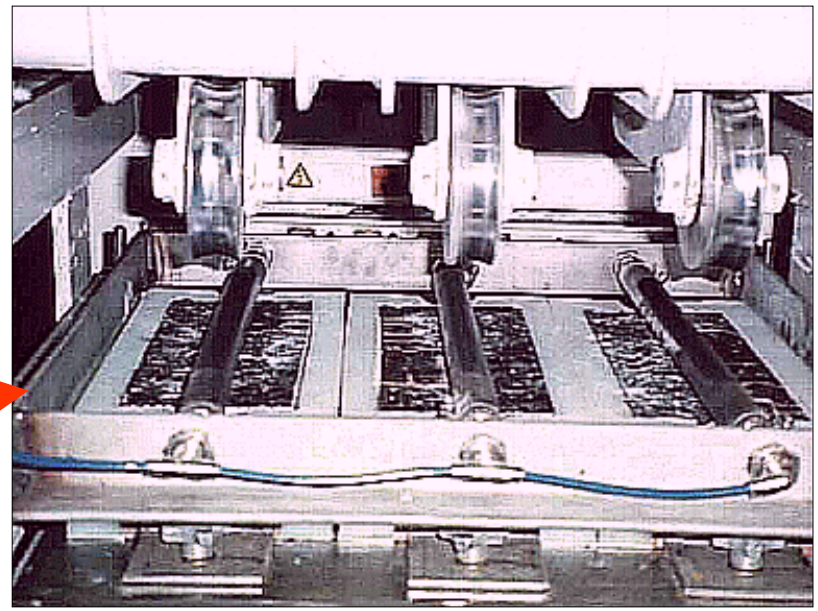
"Premature overlay failures are expensive"

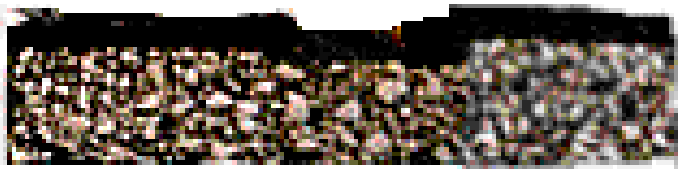
- ***Colorado -*** *'90 - Interstate stripping failures cost $12-20M*
  - *Hamburg - "disintegrator mixes"*
- ***Texas -*** *Five early Superpave projects underperform expectations*
  - *Hamburg - "all problem mixes"*
- ***Oklahoma -*** *Superpave - 9 Mo failure*
  - *Hamburg - "disintegrator mix"*
- ***Nebraska -*** *Superpave - 8 Mo failure*
  - *Hamburg - "disintegrator mix"*

Linear Kneading Compactor



Asphalt Pavement Analyzer





Hamburg Wheel Tracking

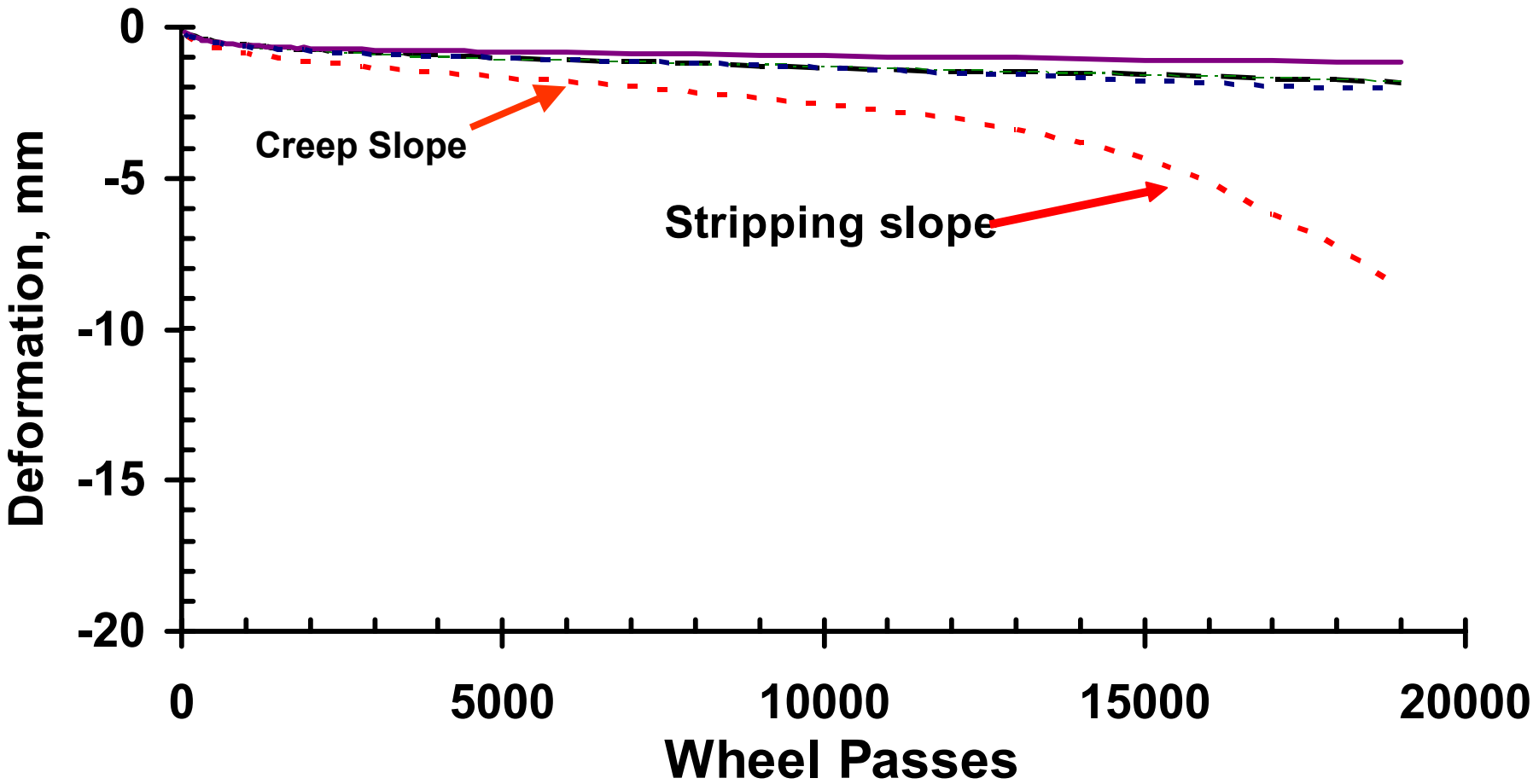
Rand:
"When
in doubt,
Hamburg!"

Hamburg definitions:
(Hines - Aschenbrenner)

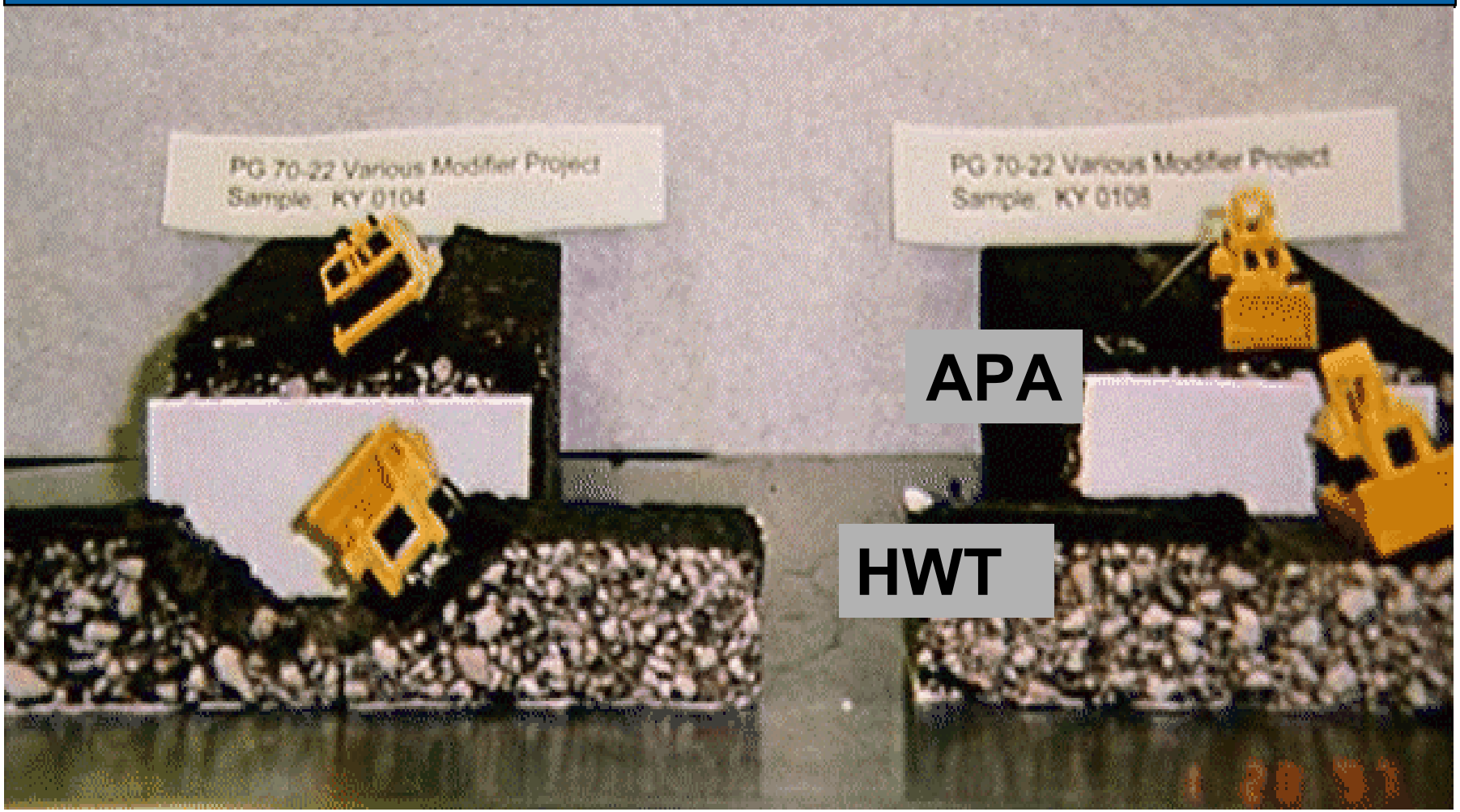
- ***Defining Failure***
  - *Creep Slope*
  - *Stripping Slope*
  - *Stripping Inflection Point*
  - *Rut Depth at X wheel passes*
- ***Mix Performance Categories***
  - *Good*
  - *High Maintenance*
  - *Complete Rehabilitation*
  - *Disintegrator*

KY PG 70-22 Mixes

Hamburg Wheel Track Test



KY I-64
Are PG 70-22's the same?



Blankenship/Myers - AAPT - 1998

Hamburg:
Conditioning & testing for heavy-duty mixes

- **Oven conditioning: Maximum** 2hrs
  - *less if hauls are shorter!*
- **Test conditions** *(Aschenbrenner)*

Climate PG grade	test temperature
PG-64	50°C
PG-58	45°C
PG-52	40°C

- **Failure - rut depth @ 20,000 wheel passes**
  - **< 4 mm - City of Hamburg**
  - **< 10 mm - Colorado DOT**
  - **< 1/2" (12.5 mm) - TXDOT**

2003: TXDOT specifies Hamburg for all HMA mixes

Traffic	Binder	Wheel-passes (min) (50°C, 12.5mm rut)
Heavy	PG 76-22	20,000
Medium	PG 70-22	15,000
Light	PG 64-22	10,000

Hamburg - TXDOT findings

- ***Better correlation to field than***
  - *Hveem Stability*
  - *Static Creep*
  - *Tex-531C (Lottman)*
- ***Identifies potential "bad actors"***
- ***Selects best antistrip***
  - ***Amines with limestone (usually)***
  - ***Lime with gravel***

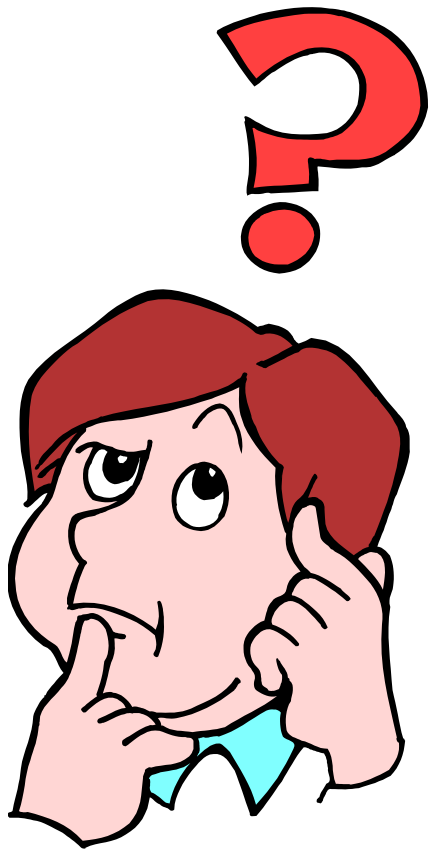
What causes a mix to fail in the Hamburg?

- ***Dale Rand's definition:***

Hamburg - torture test indicating premature failure due to:

- *weak aggregate structure*
- *inadequate binder stiffness*
- *poor volumetrics*
- *stripping - poor adhesion*
- *moisture damage (binder, fines, rock)*
- *Murphy's law*

Can binder chemistry impact moisture damage?



Binder Associated Stripping Mechanisms

- ***Water displaces AC/aggregate bonds***
  - *carboxylic acid vs pyridine (Petersen)*
  - *monovalent vs divalent ions on aggregate*
- ***Water passes through AC membrane***
  - *excess salt content or polarity (Little)*
- ***Asphalt emulsifies!***
  - *surfactant, heat, water, mechanical energy*
  - *"pore pressure" - develops under load*
    - *mechanism missed by TSR*

Binder Induced Stripping

Examples

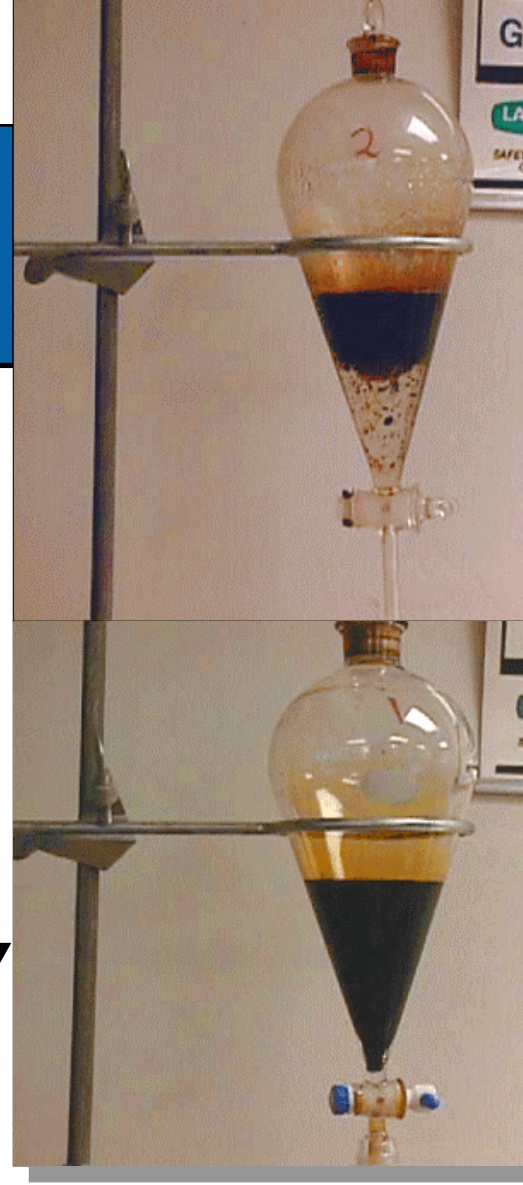
- **Crude source - CO I-70 - Copper Mountain**
- **Excessive acid to boost PG**
- **Asphalts with high salt content**
  - *Refinery caustic wash - no desalter*
  - *NaOH additive as PG booster*
  - *Acid/amine co-additives*
- **Excess asphalt emulsifiers**
  - *Heavy-crude emulsion residue developed as fuel*

I-70 - Copper Mountain

- ***Fall '92: CDOT placed 70k tons - $4MM)***
- ***Winter: Moisture-induced raveling***
- ***Hamburg forensic study:***
  - *Problem with one source of AC-10*
  - *Antistrip solutions don't help*
  - *Mix good with four other sources of AC-10*
- ***Project finished with AC-10 from same supplier, but different refinery & crude***
  - *Performance OK*

Asian Experience

- **Cheap Ven-like asphalt?**
- **Hamburg?**
  - **disintegrator mix - worst ever!**
  - **asphalt emulsified?**
- **Investigation?**
  - **AC source responsible for early pavement failures**
    - < 2 years to rehab
- **Hypothesis?**
  - **Heavy-crude emulsion residue**



What about Modifiers?

Anti-strips / ***amines-lime***

Polymers / Crumb-Rubber

Gelling agents / thixotropes

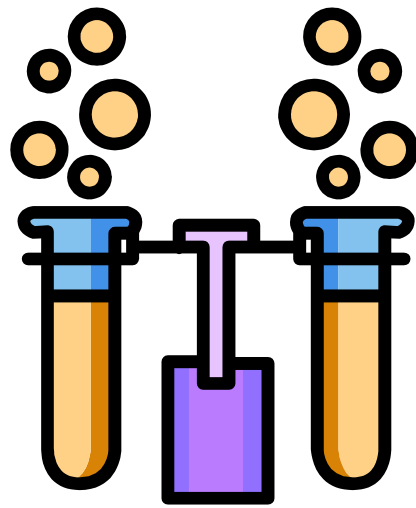
Acids & bases

Aldehyde / Acid

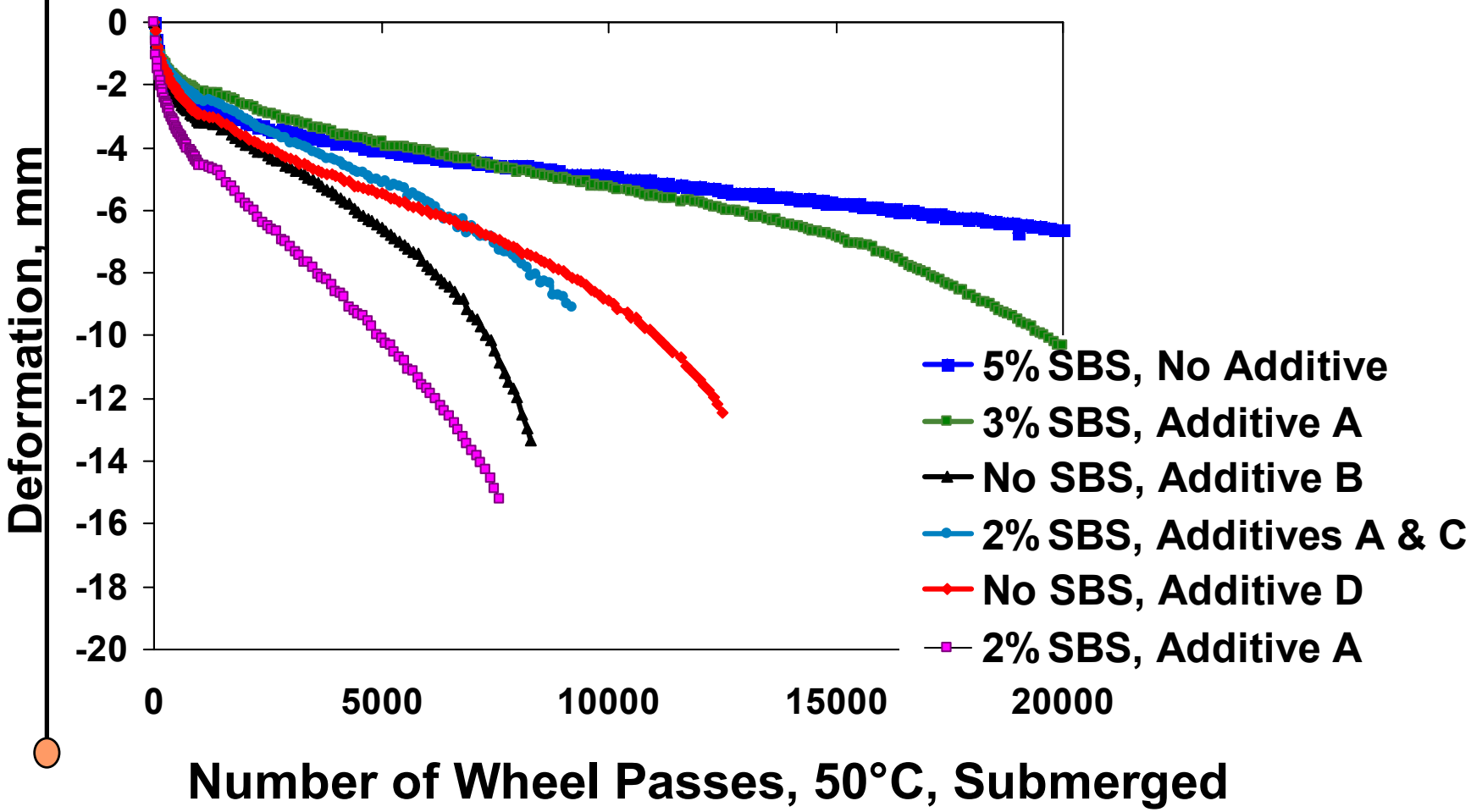
Extender oils

Asphalt extenders / Sulfur, Gilsonite, TLA

Odor masks



PG 64-34 / Different Modifiers
Hamburg Wheel Tracking

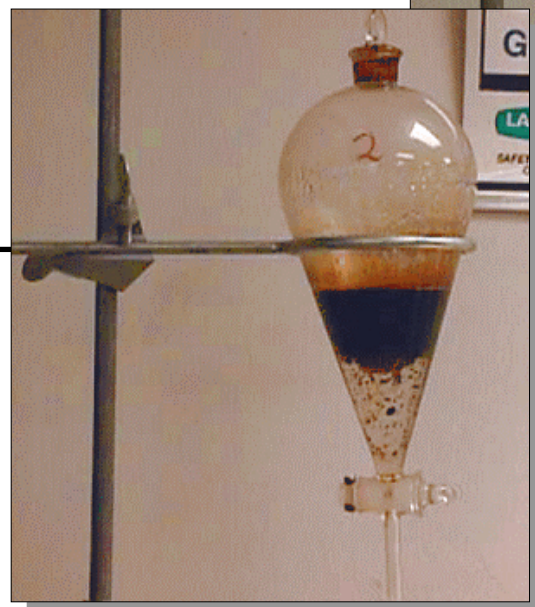


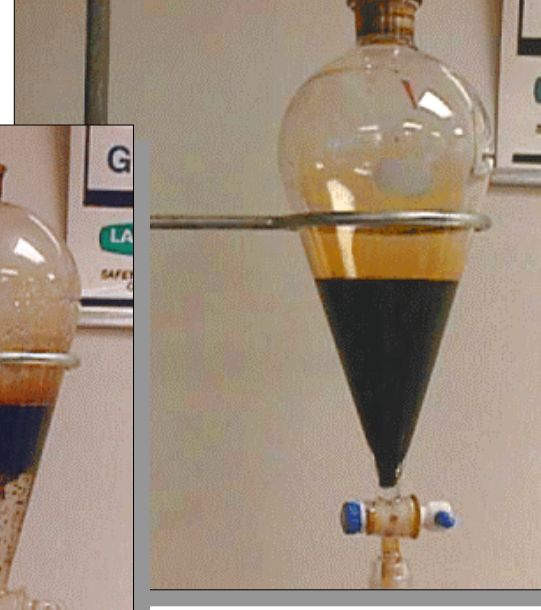
1999 - Oklahoma Overlay failure <1 year

Forensics

- Mix satisfied SuperPave criteria
- Hamburg - disintegrator mix
- Polymer/Acid modified AC
- Contractor adds amine antistrip
- Additional amine reduces TSR

KDOT Study - H_3PO_4 + amine

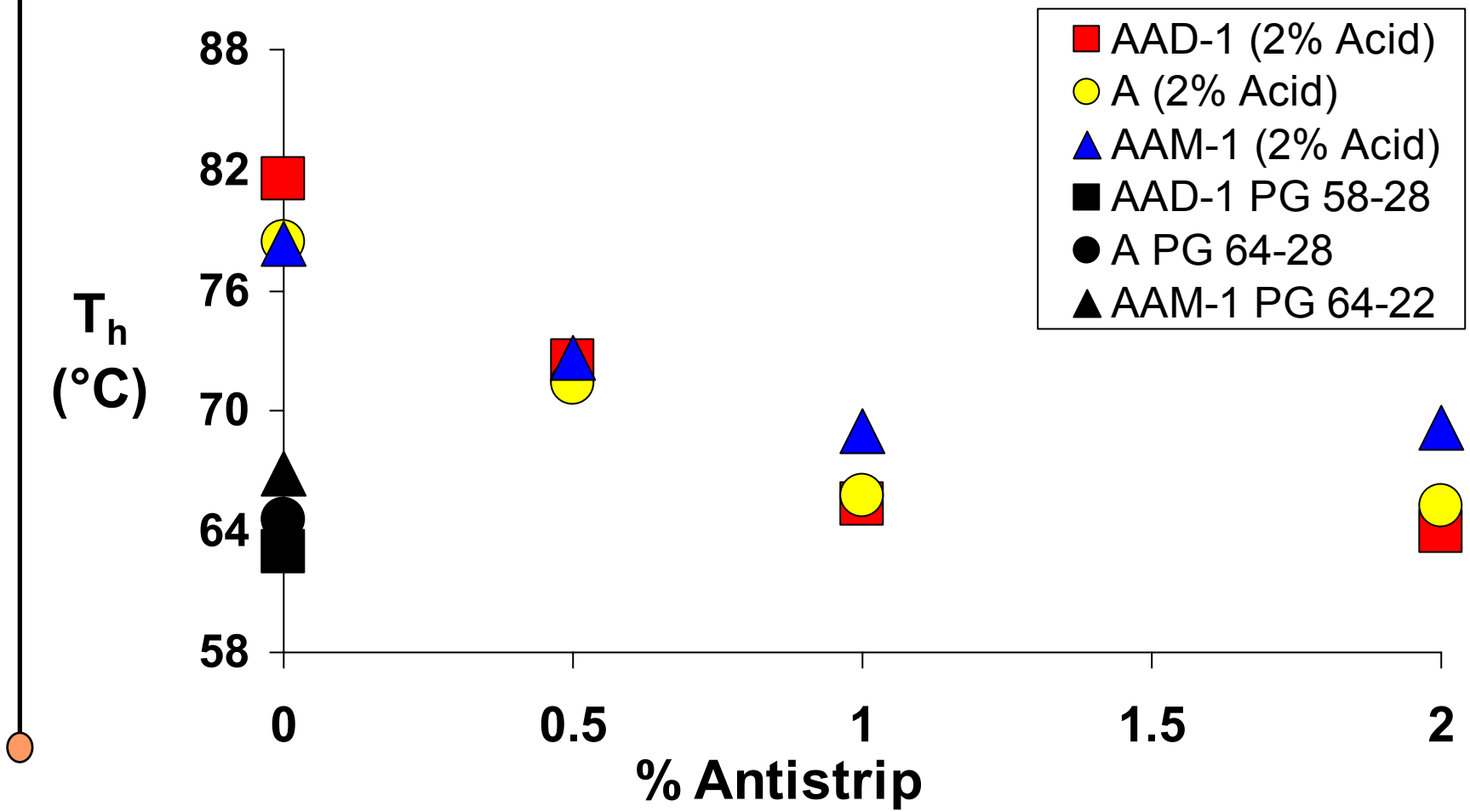




- Branthaver's 'Separatory Funnel' Test
  - pH
  - emulsification / affinity for water
- Superpave Performance Grading
  - DSR
  - BBR

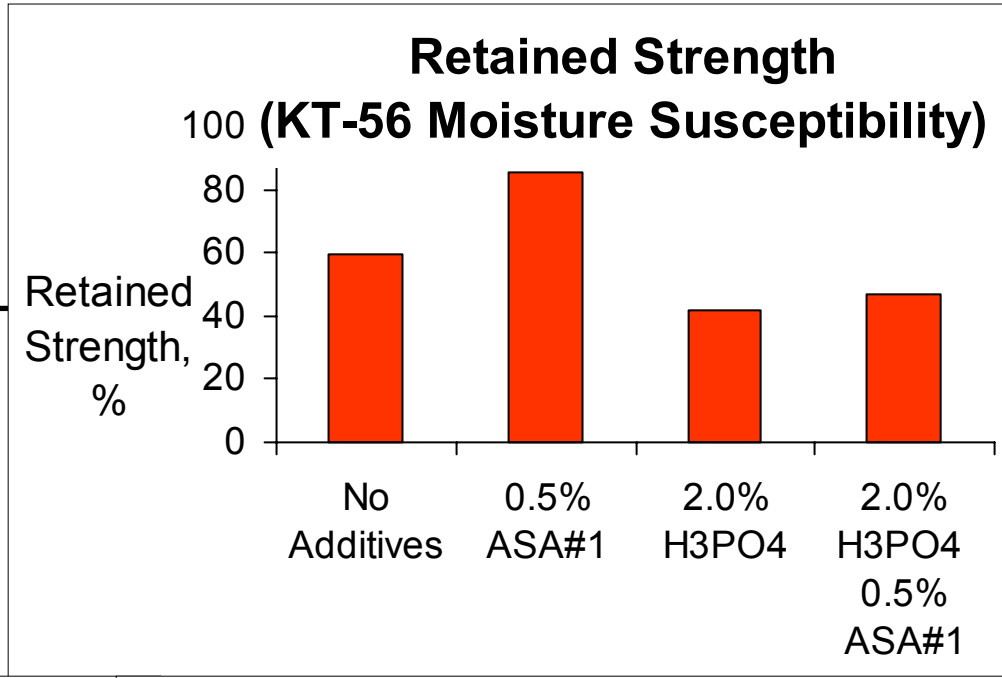
- Bishara, et. al., TRB, 2001
- Fager, et. al., AAPT, 2002

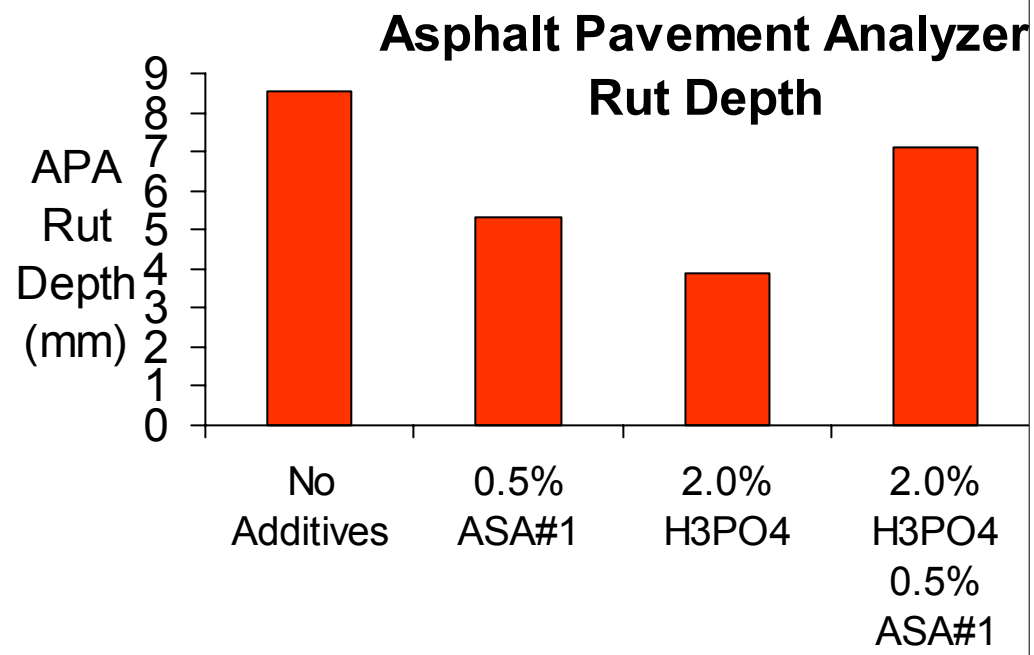
Effect of ASA #1 on ACs Modified with 2% H_3PO_4

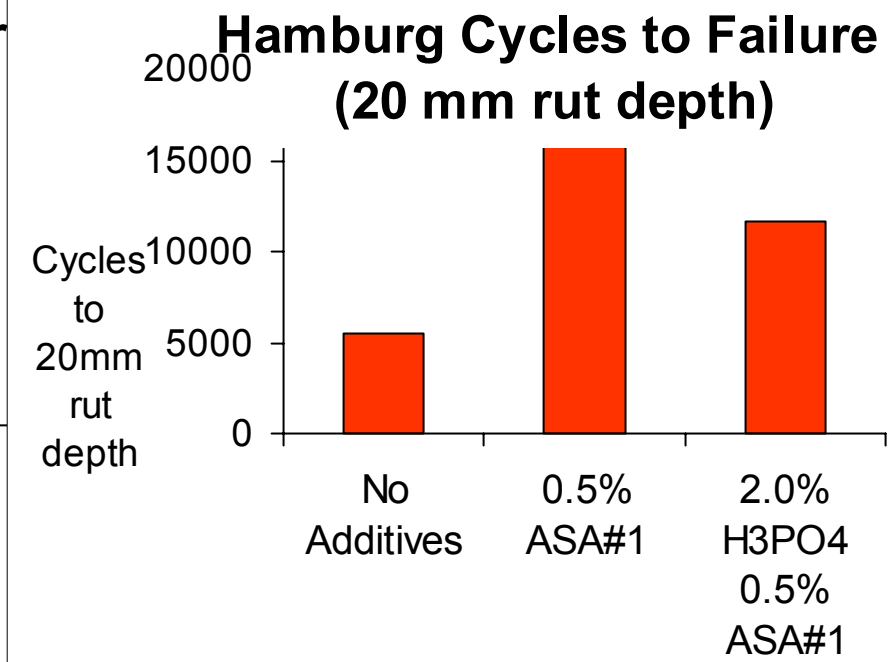


Kansas Acid-Base Study

Rutting / Moisture Results







Filler surface chemistry matters too!

Dust

Carbon black

P-200

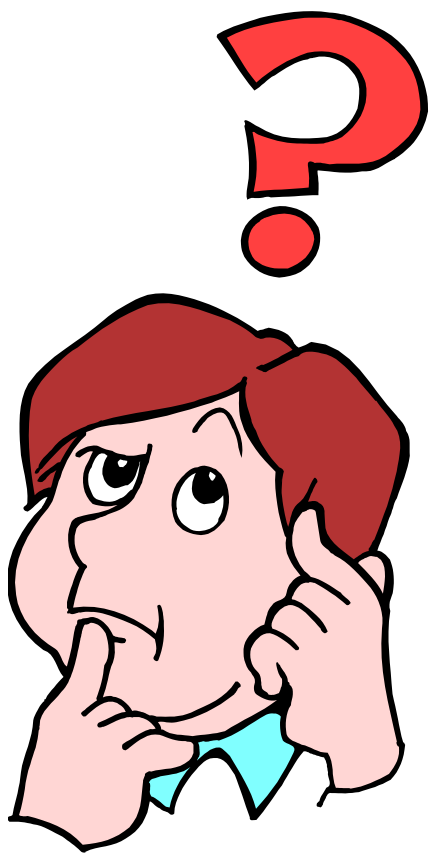
Clay

Sawdust

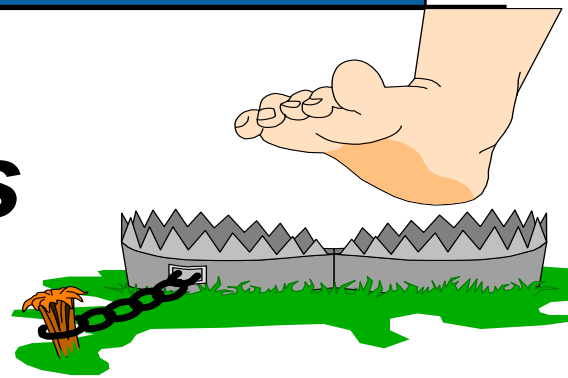
Lime

Baghouse fines

TLA



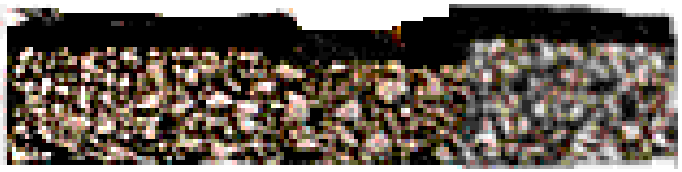
CLAY
Moisture enemy #1



- ***Moisture trap - Swells***
- ***Asphalt emulsifier***
  - *Stable even to freeze-thaw*
  - *Heat, water, AC, clay, shear*
  - *Immersion-compression tests do not predict damage severity*
  - *Hamburg works well*

Quantifying surface activity

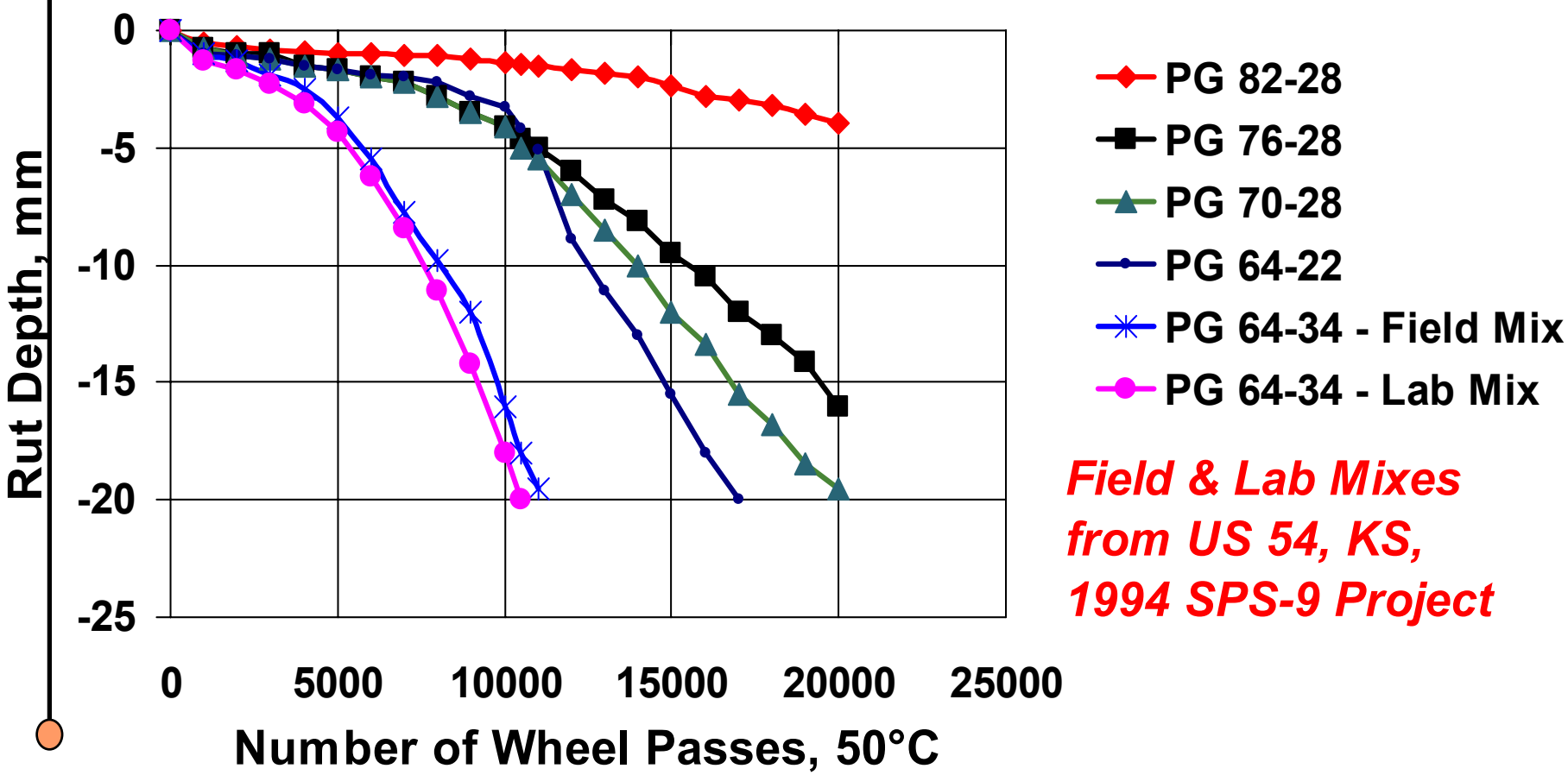
- ***Sand Equivalent***
  - *Poor Sensitivity?*
  - *Limits too low?*
- ***Methylene Blue***
  - *Quantitative!*
  - *Identify surface active fines*
    - *Aschenbrenner, Kandhal*
- ***Surface Energy***
  - *Binder/Aggregate in presence of water*
    - *Lytton, Little*



Surface activity in other fines!

Rand:
When
in doubt!

Hamburg Wheel Tracking Resistance to Rutting of PGAB's



Field & Lab Mixes from US 54, KS, 1994 SPS-9 Project

Specification Recommendations:

- ***PG binder testing/certification***
  - ***Confirm PG grade following amine addition***
    - *Liquid antistrips added before PG binder certification (Iowa DOT Draft Specification)*
    - *Binder supplier adds amines before certification (NDOR)*
  - ***Separatory funnel test for pH & re-emulsification***
    - *Branthaver*

Specification Recommendations:

Wheel-track tests for moisture damage

- ***MAXIMUM 2 hour oven heating***
  - *less if field conditions dictate.*
  - *Avoid re-heating any mixes for the HWT or chances of false positives are risky!*
- ***Adjust test conditions for climate***
- ***Adjust failure criteria for traffic (ESALs)***
- ***Test field mix or cores to confirm lab design***

Thanks!